N73-17058

MACHINING OF LOW PERCENTAGE BERYLLIUM COPPER ALLOYS

by John G. Habermeyer
Safety Officer - Ames Research Center

Last year while talking with the Safety Director of a large corporation, I asked how they handled the machining of low percentage beryllium alloys. He explained they handled all their beryllium alloys in their controlled machine facilities. However, occasionally they received information that some machining of the low percentage alloys had or was being performed in one of the non-controlled shop areas. I inquired whether they had ever taken breathing zone samples during the machining of these low percentage alloys. He said no, in fact on a few occasions they had rushed out to one of the non-controlled areas to take air samples but the job mysteriously disappeared.

Earlier this year I received word that our machine branch was going to do some machining of a two percent beryllium alloy. I decided this was a golden opportunity to make our own evaluations.

Beryllium was discovered as the oxide in beryl and in emerald in 1798 by Vanquelin. In 1828 it was isolated as the metal, by Wohler and by Bussy, independently. It is estimated to be equal to boron and cobalt in abundance and make up approximately 0.001 per cent of the earth's crust.

Beryllium is not a normal constituent of living matter and during the first eighty-eight years after its discovery, it was generally regarded as biologically inert. In 1882, Blake wrote that beryllium had the general physiologic effects of aluminum and iron. The first significant evidence in the literature concerning occupational beryllium poisoning in workers was reported in 1933 by Weber and Engelhardt. They described the occurrence of this clinical disease in a group of employees in a German plant engaged in the extraction of beryllium from beryl ore. The ill effects were ascribed to the associated anion fluoride. Additional cases of the disease were reported by Gelman in 1936, Berkovitz and Izreal in 1940, Meyer Wurm and Ruger in 1942. These European reports received little attention. Until the beginning of World War II, beryllium was generally accepted as an entirely innocuous substance in this country.

In 1939, when the large-scale development and production of the fluorescent lamp started, increasing amounts of ore were processed in this country, most of it imported from Brazil. The requirements of the fluorescent lamp and the neon sign manufactures, however; produced a sharp increase in the production and processing of beryllium oxide, the trouble started there.

The three major manufactures of fluorescent lamp in the United States started about the same time. The phosphors used to coat the glass tubes were very similar, although those used by one of the companies contained about twice as much beryllium oxide as the others. None of these manufacturers escaped without a share of cases, but the one using the high beryllium phosphor gained the unfortunate distinction of having the first case and the greatest number of cases.

The fact that beryllium, beryllium compounds and beryllium alloys are toxic, is accepted now. Beryllium is the know causative agent that is responsible for the occupational illness characteristics to the industry. Although number four in atomic number, beryllium is number one in toxicity, of all the metals. It must really try harder than the rest.

The beryllium diseases we are concerned with here are respiratory illness and skin reactions. Primarily, respiratory illness is of concern. As you know, this illness develops from the inhalation of dusts, fumes, or mists and concentrations estimated to be no greater than 0.1 ug./m3, have resulted in chronic illness among residents living near an extraction plant. Everyone agrees beryllium is toxic but considerable controversy exists as to just how toxic. Most agree the limits are too stringent, yet they are attainable by application of the proper controls and are based on case histories and laboratory data. Adherence to these controls for exposure proposed by the U. S. Atomic Energy Commission in 1948 and still accepted today, has limited beryllium disease. These guidelines proposed and adhered to are:

(1) The in-plant atmospheric average concentration of beryllium should not exceed 2 ug/M3, throughout an eight hour day.
(2) Even though the daily average might be within the above limit, no person should be exposed to a concentration of 25 ug/M3 for any period of time, however short.
(3) In the neighborhood of a plant handling beryllium compounds, the average monthly concentration at the breathing zone should not exceed 0.01 ug/M3.

Although one must consider the chemical or alloy state of the beryllium, the particles sizes, etc., the industrial hygenist must rely on the guidelines as appropriate for the total airborne beryllium and reduce as far as possible any direct contact between the workers and the dusts of beryllium containing substances.

Our interest in this problem at Ames Research Center was precipitated by an extensive program planned, using two percent beryllium in copper alloy for castings and subsequent extensive machining. At the outset of this set of tests, only the initial one was comtemplated. Samples were taken to assess for the machinists, the airborne beryllium present during different machining modes. The samplers used during each machining test were placed around the test area to obtain the concentrations of airborne beryllium present in adjacent work stations and special emphasis was made to obtain breathing zone samples for the lathe operator's position. The tests were performed in as short a time as possible due to the limited casting size available. Only total air samples were obtained during the machinging surveillance tests to assess the total airborne beryllium and no particle size assessments were made due to the limited sampling time.

Information regarding similar machining operations obtained from agencies surveying this type of work and machine shop personnel active in machining operations indicated no problem would exist at the 2% alloy level. We had some doubts that this was completely true, therefore, the first sample set was taken as a screening test with a minimal number of samples. This first cutting on the rough casting was performed rather haphazardly by the machinist, who was confident no problem existing and, therefore unknowingly, presented pretty near the type of sample one seldom gets, representing an actual unsurveilled condition. He was in error. The results of this test showed the normal dry machining used, created 45.2 ug/M3 of airborne beryllium in the operator's breathing zone and 2.3 ug/M3 at an adjacent machine working area. This test also showed that under the same operating conditions, a small shop vacuum system placed over the tool, effectively removed the airborne beryllium and the breathing zone sample showed only 0.2 ug/M3. The results of this first survey created a slight furor since it had been anticipated by the shop people that this machining could be performed dry with no restrictions. Therefore, another sample run was scheduled to supercede this one which to then was obviously in gross error.

In the meantime; an attempt was made to educate these people who were used to dealing in fractions of tons to just how small a ug was. Evidently this education was effective for the second run became a typical one for surveillance, wherein everything is done to minimize the situation. The cutting tool was changed for a smaller, sharper tool to produce a smoother cut and the lathe and castings were precleaned. The results obtained on the air sample taken on this second run did show the precautions had some effect but the breathing zone sample still contained 8.9 ug/M3 and the adjacent lathe breathing zone contained 4.2 ug/M3. The results of this survey created an even bigger furor since so many precautions had been taken to minimize the airborne particles.

At this point the constant education effort we were using on the shop personnel as to the actual size of the ug and the size of a cubic meter of air was convincing them the problem was indeed real. A third sample run was scheduled and an interested local agency was invited to participate in the sampling and analysis since they were advocators of the 2% beryllium in copper alloy machining being non-restrictive. This test was established to include a wet machine operation which was preferable to vacuum system machining operation to the machinists. The results of this test showed 27.6 ug/M3 of airborne beryllium in the breathing zone during the dry machining and 0.20 ug/M3 during the wet machining. All the surroundings samples were below 2 ug/M3.

No furor resulting from this survey but some analytical ambiguities existed on some of the split filter paper and additional analytical data was sought. Therefore, a fourth run was scheduled to duplicate the third run and obtain adequate samples to allow quartering the sample filters for analysis by four independent laboratories who had shown an interest in this problem. The results of the fourth sample set showed breathing zone concentrations as high as 20.8 ug/M3 for the dry machining and less than 0.5 ug/M3 for the wet machining.

Comparing the data from the four tests must be done semi-empirically since none of these tests were designed as experiments. The analyses were made to establish the airborne beryllium present during the changes in operating conditions imposed by the machine shop personnel. Many changing operating parameters were present from test to test. A few have been mentioned such as vacuum systems, water sprays, tool condition and different lathes. Other conditions changing during the series of tests considered important are: The depth of the cut, the revolutions per minute of the casting, the drafts present in the large building, and the exterior surface of the casting, which was extremely rough for the first tests and smooth for the subsequent tests.

The interesting result of the tests performed is the fact that every test made using the dry machining showed airborne concentrations in excess of the T.L.V. of 2 ug/M3.

The comparison of the data from the dry machining shows this clearly:

AIRBORNE BERYLLIUM DATA

NASA-ARC BLDG. N-220 MACHINE SHOP

COMPILED DATA FROM FOUR TESTS

	MAX. ug/M3 Beryllium for Dry Machining			
SAMPLER LOCATION:	1st TEST	2nd TEST	3rd TEST	4th TEST
Breathing zone for Machine Operator	45.2	8.85	27.6	20.8

Any future program concerning this type of beryllium alloy machining should be designed as an analytical program wherein the operating parameters can be controlled, additional samples obtained, and sufficient cutting time available to obtain particle size separated samples.

In closing, we became more aware of two well known but often overlooked ideas in creating safe working conditions.

First, don't believe in the popular opinion of people doing the work if there is any possibility of checking the belief. After all, not too long ago in some societies it was generally believed that women became pregnant from walking in the moonlight.

Second, talk to the employees involved in performing the tasks. They may not be aware of the small quantities considered toxic until you educate them. After educating people they will cooperate with the establishment. Look at our college campuses - a classic example.